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COMPUTATION IN JUNIOR HIGH SCHOOL MATHEMATICS.

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With the present tendency of including so much geometric and algebraic material in the junior high school and of devoting so much time to informational subjects in many vocations and avocations, one may well ask the question, "Is there sufficient time left to give the necessary drill and practice to make pupils proficient in the four fundamental operations with integral numbers and with common and decimal fractions?"

The writer does not wish to find any fault with or to throw any discouragement upon the useful work in geometry and algebra that is being advocated in these grades, for it is, indeed, the hope of solving the junior high school problem in mathematics, but he rather desires to sound a warning against carrying any movement to an extreme.

With the lack of adequate *constructive supervision* in junior high school mathematics, there is great danger of teachers' becoming so highly enthused about the multiplicity of informational subjects that are now being advocated for the curriculum in mathematics that pupils may be left woefully weak in arithmetic skill, the very point that needs most careful attention, because it is upon this point that schools meet adverse criticisms on every hand in the business and professional world. If the new courses of study do not make ample provision for this phase of the work, it is evident that the pendulum will soon swing back and that much of our hope of progress will be lost.

The writer contends that work in computation of one phase or another should be done almost daily throughout the three years of the junior high school, rather than to give the whole time to it during a definite part of the course. Some advocates of certain courses in the reorganization say: "It may be assumed that the pupil has become proficient in the four fundamental operations with integral and fractional numbers in the first six grades." Such an assumption is questionable. The teacher of junior high school grades knows, and she knows beyond the question of a doubt, that the average seventh-grade pupil is not familiar with the exact meaning of such words as sum, difference, product, quotient, factor; that the average pupil does not know how to add, subtract, multiply, or divide two small fractions; that the average pupil does not know how to write such examples with any degree of accuracy.

This is sufficient evidence that work in computation requires some very careful attention; even some very systematic attention from the very beginning of the junior high school work for a period of time determined altogether by the condition and response of the class.

Then after the class realizes the situation and understands *how* to perform the various operations it is necessary and sufficient to continue the drill for a few minutes daily. Much of this work should be oral, although at times work may be given which requires the use of pencil.

In all work in computation or arithmetic drill pupils should be made conscious of approximating results, of using short cuts, and of using constant checks. When pupils are trained to use common sense in checking their answers, many unexcusable errors will be eliminated; *e.g.*, the pupil will not say that $\frac{1}{2} + \frac{1}{4} = \frac{2}{6}$, because he will observe that $\frac{1}{2}$ is more than $\frac{2}{6}$ or $\frac{1}{3}$; or he will not say that $102 \times 345 = 4{,}140$, because he knows that $100 \times 345 = 34{,}500$; therefore, 102×345 must be more than 34,500.

Considerable emphasis should be placed upon "short cuts"; especially where the "short cut" will save time and labor, and where it is also less likely to cause error. A few examples follow:

1. In multiplying 360 by $\frac{3}{4}$ it would be unfortunate to multiply first by 3 and then divide by 4.

2. To multiply a number by 15, multiply by 10, and then add $\frac{1}{2}$ of the product to the product; to multiply a number by 35, multiply by 30, and then add $\frac{1}{6}$ of the product to the product, etc.

3. To multiply by 25, annex two zeroes and divide by 4, etc.

When emphasis is placed upon approximating results, upon using short cuts, and upon constant checks, the abstract work really becomes thought work, and *original* thinking will be exercised by the pupil similar to that necessary in solving word problems.

The criticism is sometimes offered that the pupil grows tired and weary of so much drill work. The skillful and tactful teacher will never permit this work to become a drudgery; on the contrary, the work will be the pupil's delight. This work may be presented in such a multiplicity of ways and forms that the pupil will ask for more than the teacher can afford to give. It may be given in the nature of games; in the nature of friendly contests; in a way that the pupil appreciates the practical side of it; constant use may be made of it in the presentation of new topics and problems.

Assuming that this hypothesis has been proved, namely, that we can not afford to sacrifice facility in computation at the expense of voluminous geometric and algebraic material in the junior high school, the following suggestions are given relative to obtaining this facility:

1. Straightforward drills may be given upon the four fundamentals with integral and fractional numbers by:

(*a*) Placing tables of numbers on the board and letting pupils name results as teacher points to them.

(*b*) Using the picture of a wheel, placing numbers at the ends of the spokes, and a number in the center to be added, subtracted, multiplied or divided. The point is to see who can spin the wheel the fastest.

(*c*) Using relay races.

(*d*) Having pupils multiply a series of small numbers by a given number and then adding or subtracting another given number.

(*e*) The use of number cards.

(*f*) The use of timed exercises.

2. Applications of these abstract drills in calculating:

(*a*) Grocery bills.

(*b*) Drygoods bills.

(*c*) Personal accounts.
(*d*) Gas bills.
(*e*) Light bills.
(*f*) Pay rolls, etc.

3. Applications to problems in percentage:

(*a*) Changing per cents. to fractions and vice versa.

(*b*) In the solution of problems involving per cents. Many "short cuts" may be used in this work.

4. Formulæ in geometric work. Much stress should be placed upon substituting in formulæ, and this furnishes drill in common and decimal fractions as well as in integral numbers. The following are examples of familiar formulæ:

$$p = 2(l + w); \qquad c = 2\pi r;$$
$$A = ab; \qquad A = \pi r^2;$$
$$A = \tfrac{1}{2} ab; \qquad V = aB;$$
$$A = \tfrac{1}{2} a(b + b'); \qquad S = 4\pi r^2.$$

Pupils may be required to solve for any one of these letters, when values for the other letters are given.

5. The work of evaluating expressions may be continued still further by substituting given values for the letters in such expressions as:

1. $bc + ad.$
2. $a^2b - cd.$
3. $\dfrac{4xy + 3(x + y)}{5x - 2y}.$

6. When the pupil has reached the point where he needs drill upon collecting similar terms, coefficients that are common and decimal fractions should be used as well as integral coefficients; *e.g.*, collect:

(*a*) $\tfrac{3}{4}a + \tfrac{1}{2}b - \tfrac{1}{2}a + \tfrac{3}{8}a + \tfrac{5}{8}b - \tfrac{1}{4}b.$
(*b*) $.75c + .48d - .2c - .32d + .86d - .34c.$

7. When the pupil has learned the law of exponents in multiplication and division, many numerical examples may be given; *e.g.*,

(*a*) What is the value of $2^4 \cdot 2^2 \cdot 2^3$?
(*b*) What is the value of the expression $\dfrac{4^2 \cdot 5^3 \cdot 3^6}{4 \cdot 3^2 \cdot 5^4}$

8. In multiplication and division of monomial factors, coefficients that are common fractions and decimal fractions should frequently be used; *e.g.*,

(*a*) What is $\frac{2}{3}b \div \frac{7}{8}b$?
(*b*) What is $\frac{5}{6}a \div \frac{2}{3}a$?
(*c*) What is $.45d \times .56d$?
(*d*) What is $.21c^3 \div .32c^2$?

9. The study of special products offers an excellent opportunity for numerical applications. The following are examples:

$$(a)\ 41\cdot 39 = (40+1)(40-1) = 1600-1 = 1599.$$

$$(b)\ 83\cdot 77 = (80+3)(80-3) = 6400-9 = 6391.$$

$$(c)\ 61^2 = (60+1)^2 = 3600+120+1 = 3721.$$

$$(d)\ 82^2 = (80+2)^2 = 6400+320+4 = 6724.$$

$$(e)\ 79^2 = (80-1)^2 = 6400-160+1 = 6241.$$

10. It will be of interest to the pupil to become acquainted with certain useful generalizations in addition and subtraction of fractions; *e.g.*,

(*a*) $1/b + 1/a = \frac{a+b}{ab}$; this shows how he may readily find the sum of two numerical unit fractions.

(*b*) $1/b - 1/a = \frac{a-b}{ab}$; this shows how the difference between two numerical fractions whose numerator is 1 may be found at a glance.

11. The study of quadratic equations offers further opportunity for numerical drills. When the equation is solved by completing the square, the following points are involved:

(*a*) Division involving fractional quotients.

(*b*) Dividing a fractional coefficient by 2.

(*c*) Squaring the resulting quotient.

(*d*) Adding the square of the resulting quotient to each member, and this involves addition of fractional numbers and mixed numbers.

(*f*) Further addition of integral, fractional and mixed numbers.

12. When the quadratic equation is solved by substituting in the quadratic formula, all the fundamental operations are involved, including those of raising to a power and of extracting the square root.

13. In the study of surds application may again be made with numerical expressions, both in simplifying surds and in performing all of the fundamental operations; *e.g.*,

(*a*) $\sqrt{27} = 3\sqrt{3} = 3(1.732) = 5.196.$

(*b*) $$\begin{aligned} \sqrt{32} - \sqrt{8} + \sqrt{128} &= 4\sqrt{2} - 2\sqrt{2} + 8\sqrt{2} \\ &= 10\sqrt{2} \\ &= 10(1.414) \\ &= 14.14. \end{aligned}$$

(*c*) $5\sqrt{3} \cdot 2\sqrt{3} = 10 \cdot 3 = 30$

(*d*) $30\sqrt{5} \div 15\sqrt{5} = 2.$

14. The study of numerical trigonometry, if included in the junior high school course, offers a splendid opportunity to give the pupil a final drill on accuracy in numerical computation. It will make him especially proficient in manipulating decimal fractions, a point of great importance.